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Concerning the Character of Intraspecific and Interspecific Relationships between Microorganisms.

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During recent years the question of the nature of intraspecific and interspecific relationships has been widely discussed in our journals. A faction of investigators support T.D. Lysenko, who considers the relationships between related species as antagonistic; while he considers the absence of antagonism as well as mutual assistance as characteristic for the interrelations between the individuals of one and the same species. Others question these assertions and consider that they are not corroborated by facts.

It is clear that this argument can be settled only by the method of accumulating the scientific facts and impartially analyzing them. Meanwhile, in our scientific press, are found articles in which an extremely strange method is used for settling a given argument. In these works, the authors instead of confirming the accuracy of one viewpoint or the other with facts, follow a diametrically opposed method. They acknowledge the facts as authentic only when they correspond to their cherished conception. A similar type of work is also found in the microbiological literature. Thus, Sukhov, citing the analysis of a species given by Lysenko, asserts that since "the interrelations between related strains of viruses are, as a rule, antagonistic relationships", then "one can deduce that the suppressive member of the described strains must be referred to the qualitatively distinct forms of the species."

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In the given case, the logic of the author is completely simple. Once Lysenko said that the relationships between related species are antagonistic, then consequently, it is only necessary to detect antagonistic relationships between certain strains of a virus in order to consider them not as strains, but as related species. What such an attitude leads to, may be seen from the examples by which the author strengthens his discussion. He indicates that, by a single subinoculation through certain plants, he succeeded in changing one of the species of the tobacco mosaic virus into a different species which distinguished itself from the original only by the fact that it incited a faster course of the disease in plants, with a shortened (by 2 or 3 days) incubation period and more pronounced necroses. Thus, this new "species" distinguished itself from the original only by a little more virulence. If one should follow this line, then an innumerable multitude of strains of that or a different pathogenic microbe must be declared as different species, since they often differ markedly from each other in their virulence. This would lead to the greatest confusion in the theory as well as in the practice of microbiology, and by the gist of the matter could denote a regression to the attitudes of pleomorphism.

A similar trend of logic is characterized by the work of Mikhailov who, having detected, what to him seemed, competitive interrelations between the vaccine and virulent strains of the tularemia bacteria, makes a conclusion on this foundation that the vaccine strain is a new species in comparison with the original. Here, also, instead of a study of all the vaccine strain's special features which allow its distinguishment from the original, the correspondence or non-correspondence of the interrelations between the two strains to the Lysenko formula is taken as the basic criterion.

It appears clear that a method which does not take facts as a criterion of the verity of one position or the other, but selects a formulation which in itself is debatable, cannot be considered as a good method of scientific argument.

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What is the nature of the intraspecific and interspecific relationships in microorganisms? First of all, what is the nature of the interrelations between related species? Is it possible, on the basis of the character of the relationships between microbes, to draw a conclusion as to their specific identity, or inversely, to their difference?

The voluminous factual material accumulated by modern microbiology allows us to come to the conclusion that the interrelation between related species of microorganisms can develop not only in accordance to the principle of antagonism or mutual competition, but also on the basis of peaceful and sometimes concomitant relationships.

Examples of such a genus are extremely numerous. In particular, one could point to the normal microflora of the human body. It is known, for example, that in the large intestine of man, not causing each other harm, coexist such related species of microorganisms as the *Bacillus coli* and the *Para colobactrum*. In the mouth cavity-various species of the *Spirochaetae*, *Streptococci* and *Diplococci*. In the tonsils-close species of *Streptococci* and *Diplococci*. On the skin-various species of *Staphylococci*, etc. In this connection one can point out the numerous data made known from the practice of infectious Pathology. Such as, for example, the cases of prolonged bacteria carrying, when in the pharynx, in particular, can coexist the diphtheria and false diphtheria bacteria; in the large intestine- dysentery and *Bacilli coli*; in the respiratory tracts-various species of capsule bacteria.

On the other hand antagonistic interrelations occur more often between widely separated species of microorganisms although they may also be observed between related species. The competitive interrelations between the different molds and *Actinomyces* on the one hand and the diverse species of bacteria on the other are well known. The molds and *Actinomyces* are the most powerful producers of antibiotics which act destructively on bacteria but do not exhibit a similar activity on the other species of molds and *Actinomyces*. The microorganisms which manufacture the antibiotics, as a rule, produce such antibiotic substances that act not on the related but on the widely separate species of bacteria. It is known that the various bacteria belonging to the normal

microflora of the human body, and living in perfect harmony with each other, act antagonistically to several conditionally pathogenic fungi by inhibiting their propagation. A treatment with antibiotics, suppressing the vital activity of the normal microflora, aids the propagation of these fungi; the candidomycoses, in particular, may be a result of this.

It is important, however, to emphasize that the character of interspecies interrelations depends not only on the characteristics of the respective microorganisms, but to an important degree on the properties of the surrounding environment. With a change of these conditions, the character of the interspecies interrelations is also changed. This concerns the pathogenic as well as the nonpathogenic microorganisms. As, for example, Yugenburg, Peretts and Mostova showed that upon the roentgenization of dogs, they observed a sharp drop in the quantity of *Bacilli coli* and an increase in the number of *Paracolon* bacteria and enterococci. This effect is not connected with the action of the X-rays on the microbes, but with the action of the X-rays on the macroorganism, i. e., on the medium of the indicated bacteria's existence.

The microbic scene of the intestine is sharply changed with a change in the character of the food. This is particularly evident in children during the transfer from breast feeding to a mixed diet.

The significant and sometimes the established importance of the surrounding environment to the character of the interrelations between the individuals of the various species of microorganisms is corroborated also by the fact of the presence of the so called dysbacterioses. The latter develops as a result of a pathologic impairment in the functions of one or the other of the organs. Conditions are created favoring the development of one species of microorganisms and inhibiting the propagation of others, depending on the nature of the dysfunctions.

The concomitant relations between one or the other species, upon changes in the surrounding environment, may change to be antagonistic; or on the other hand, competitive interrelations may give way to synergistic relations.

Thus, as an example, in persons with measles, the correlation of the percentage of inoculation of the nonhemolytic and hemolytic streptococci from the tonsils is changed so that there is an increase in the quantity of the latter (Kassirskaya, Mogilevskaya and Kir'yakova). In patients with dysentery, as a rule, an expressed intestinal dysbacteriosis is noticed with a frequent predominance of the *Bacilli coli* having a weak biochemical activity (Drobinskii, Peretts and others). According to Drobinskii, a predominance of the saprogenic processes is observed in the large intestine in the chronic form of dysentery.

The phenomenon of directed (forced) antagonism, investigated in detail by Shiller, is another corroboration of the point of view expressed above. Shiller showed that microbes, which under ordinary conditions live peacefully with each other, in a condition of nitrous starvation change their characteristics. In these circumstances the

microorganisms possessing proteolytic properties begin to assimilate nitrogen from the bacteria located with them in the same medium of existence. These microorganisms although incapable of breaking down protein, begin to feed at the cost of the other bacteria, thereby entering into competitive relationships with them.

In such a manner many facts attest that the relationships between the different, and most of all, the related species of microorganisms may be diverse, depending on the conditions of their existence.

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Let us now examine the interrelations between the microorganisms of one species.

Every day microbiological practice shows that it is very often impossible to detect antagonistic interrelations between cells of the very same species of microorganisms. Often synergistic relationships are developed between them. It is known, for example, that upon introducing tularemia bacteria on a hard vitelline medium, propagation of the microbes is observed only when a sufficiently large quantity of the microorganisms are sowed. With a transfer of a single bacteria, growth will not occur. Consequently, in the given case, the growth and propagation of the bacteria are possible only with the presence of a sufficient quantity of microbes in the medium and with the presence of concomitant relationships between these microbes. Many similar examples can be cited.

However, does this imply that the intraspecies relationships of microorganisms are always, in all cases characterized by synergism alone? Does it imply, in particular, that between microbic cells of one and the same species there can never, not under any conditions, develop antagonistic relationships?

Several investigators hold to the latter point of view. Thus, Muromtsev¹ considers that "it is impossible to bring forward one fact in contradiction to this opinion." In this connection he assumes that "it is possible to formulate the conception 'species' in microorganisms as a combination of the ecological varieties or races which possess, in a natural medium of existence, a complex of similar, hereditarily attached features and characteristics (morphological, cultural, physiological and serological) and do not display antagonism in interrelations. Thus, the Muromtsev formulation coincides with Lysenko's point of view. A somewhat different approach to the question is made by Zhdanov², who considers that "a species of microbes is a community of individuals accumulated during the course of evolution which are: 1. characterized by the similarity of the morphologic, cultural and biochemical characteristics and antigenic structure within the limits of observable variability. 2. located among themselves in synergistic relationships. 3. have adapted themselves to specific conditions of existence and are capable of producing a specific disease (infectious process)." Thus, Zhdanov considers the circumstance, that microorganisms "are located among themselves in synergistic relationships" as one of the basic features of a species.

To our view, the true position of things consist of the following: truly, we do not often observe antagonistic interrelations between individuals of one species. Often, as indicated by us above, these relationships have a synergistic character, although such relationships are observed only under certain conditions. By a change in the conditions of the exterior environment, especially in the influence of unfavorable factors, antagonistic relationships may also be developed between microbes of one and the same species. In other words, the character of interrelationships between the individuals of the very same species of microorganisms depends on the conditions of their existence. Under one set of conditions these interrelations are concomitant, under another- antagonistic, under a third- neither antagonism nor synergism are to be observed.

It is known that under certain conditions of the exterior environment, characterized by an insufficiency of nutritious materials and an accumulation of metabolic and catabolic products of the microorganisms in the medium, an oppression of the microbes' vital activity is observed. This can, for instance, be observed in the propagation of a bacterial population in vitro. Thus, as a result of the bacterial multiplication, begins a general lowering in the energy of the population's vital activity that clearly does not correspond to the interests of the species. One could say that under these conditions the bacteria themselves prepare the groundwork for their own destruction. The microorganisms, proven adapted for the struggle for existence in the given circumstances, by consuming the nutritious substratum and excreting the products of the vital activity into the surrounding environment, contribute to the destruction of the other less adapted organisms of the same species. It is difficult to believe that this process is accomplished as a result of a concomitant activity of the population's individuals. It is more probable to assume that here, between the separate individuals are developed antagonistic relationships in the struggle for the nutritious substratum. A similar condition develops in the case effected by antibiotics, a bacteriophage or other factors unfavorable to the microbial population.

Principally the same interrelations also hold sway in the propagation of pathogenic bacteria and viruses in a host organism. In this case it is impossible to agree with Zhdanov's point of view; he indicates that expressly by the example of the viruses, is it clearly corroborated that the intraspecies relationships are characterized by synergism. In support of this point of view, he brings forward this fact; that upon a successive increase of the doses of a virus, a successive rise of the pathogenic effect is observed. However, as it seems to us, this fact cannot serve as a conclusive proof that between the separate elementary members of a virus, always exist only concomitant relationships.

If a direct proportional dependence between the dose of the virus and the degree of its virulence is observed, then it is only within known limits and with the observance of known conditions. After reaching a certain limit, a further increase of the viral dosage is not accompanied by a further strengthening of the pathogenic effect. For

instance, if an intracerebral injection of a given dose of a fixed rabies virus causes the death of 100 % of the animals, then the analogous effect frequently stipulates even millimultipile doses of the virus. Thereby, under these conditions, the following increase of the dose may not be accompanied by a shortening of the incubation period. In an infection by the tuberculosis bacteria, the injection of a few bacterial cells often produce a disease of such a character and gravity as if several thousand bacteria had been injected.

Sukhov³ indicates that " the mutual limitation of reproduction stipulated by the activity of the individual elements of a virus represents a variance between them. However, this variance conveys neither antagonism nor oppression of the population, but is only a consequence of the population reaching the limit concentration that in the best manner supports the species in nature, protects it from the intrusion of other related species and contributes to its welfare." If the first part of the given quotation does not incite a contradiction, then it is difficult to agree with the second part. It is incomprehensible, for example, how the death of the rabies virus, coming after its excessive propagation in the brain and the following death of its host, can contribute to the welfare of the given virus. It is also impossible to agree that the indicated correlations are not antagonistic and do not lead to the suppression of the population, because in actuality it occurs. To wit, the depression of the vital activity of the population and the lowering of its biological activity.

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All of the above enables us to come to the conclusion that the character of the intraspecies as well as the interspecies interrelations is determined not only by the properties of its own microbes, but also by the conditions of their existence.

With a change of the environmental conditions, the character of these interrelations may also be changed. An intraspecies struggle, in particular, begins there and then, where and when conditions of the environment are created that are unfavorable for the growth of the given species.

Conclusions

1. The intraspecies and interspecies relationships of microorganisms are not something hard and fast. They are not always relationships of either pure synergism or pure antagonism. Their character can change depending upon the concrete conditions of the microorganisms' existence.
2. The character of intraspecific and interspecific relationships cannot serve as a criterion for the determination of the microorganisms' species.

1. S. N. Murontsev. *Izmenchivost' mikroorganizmov i problema immuniteta*. Sel'khozgiz, 1953. p. 46.
2. V. M. Zhdanov. *Opredelitel' virusov cheloveka i zhivotnykh*. M., Izd. AMN SSSR, 1953. p. 36.
3. K. S. Sukhov. *Virusy*. Izd. Akademii Nauk SSSR, M., 1956, p. 254.

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